# System and Method for Providing Efficient and Secure Data Exchange Using Strip Information Elements

## RELATED APPLICATIONS

This application is related to the following co-pending U.S. Patent Application filed on the same day as the present application and having the same inventor and assignee: "System and Method for Distributing Proximity Information Using a Two-Tiered Bootstrap Process," (Docket No. AUS9-2001-0563-US1) by Barillaud and assigned to the IBM Corporation.

## BACKGROUND OF THE INVENTION

### 1. Technical Field

The present invention relates in general to a system and method for exchanging data between computing devices. More particularly, the present invention relates to a system and method for using strip information elements to provide secure data exchange and efficient bandwidth utilization.

### 2. Description of the Related Art

In the pervasive device environment, handheld devices communicate with external entities. When the information exchange requires more than a single and simple communication exchange, one of the best approaches to solve the problem is to have an agent within the handheld computing device that takes care of the communication exchange. An agent is a program that performs information gathering or processing task in the background. Typically,

an agent is given a very small and well-defined task. Tasks involved in the communication exchange include requesting and receiving the proper information content type. Examples of information content are text, non-real time video, real time video, and music. Bandwidth resources are wasted when a service provider sends text and video information to a device that is capable of processing text, but not video. Another varying factor in handheld devices is the screen. Many pagers have a small, monochrome screen, while laptop computers, however, often have larger, color screens. Bandwidth resources are wasted when a service provider sends information to the paging device that the paging device is not able to display properly. Unfortunately, there is no unique, common agent able to handle the different types of communication for the different types of information content.

The type and amount of electronic devices for information exchange are increasing and improving at an exceptional rate due to the investments in technology research. Mobile telephones today, for example, are able to communicate on multiple frequencies as well as multiple air interfaces (analog, CDMA, TDMA, etc.). Mobile phones are also useful for more than just for phone conversations. For example, many mobile telephones can access the Internet or a host of services that provide information. Other handheld communication devices also have greatly improved capabilities in comparison to devices offered only a few years ago. Pagers can now transmit messages as well as access Internet information. Many Personal Digital Assistants (PDA's) have wireless connections that allow the PDA to send and receive wireless data and access computer

networks, such as the Internet. With the increasing quantity and quality of portable electronic devices, a challenge is to develop a way to provide sufficient information exchange to a handheld device without using unnecessary bandwidth and maintaining security.

What is needed, therefore, is an information distribution configuration that is adaptable to the constraints and features provided in any number of possible handheld devices.

**SUMMARY**

It has been discovered that by sending strip information elements, unnecessary data is not sent and bandwidth is minimized. Strip Information Elements (SIE's) do not carry the complete information, but carry the elements necessary to retrieve, format, and display the information. A local agent in the handheld device manages the reception of the strip information elements. When the SIE arrives at the handheld, the local agent authenticates it to prevent distribution of unauthorized information. Each SIE contains an Event ID which identifies an event that corresponds to downloadable information. The agent compares the event ID with the ID of the event to which the user has subscribed. After the security checking is done, the SIE is under control of the local agent that scans the different fields in the SIE and makes decisions according to the content of the field.

The strip information element includes other fields to aid in the proper management of information. The Execution field includes information that informs the handheld device whether data may be retrieved immediately or on user request. Live video may be set to download immediately, while an instant replay may be set to download on user request. The Lifecycle field includes information that determines whether the information may be kept after been processed by the local agent. Information readily available may be stored on the handheld device, while proprietary data may not. The Configuration field includes the service time to live, which informs the handheld device how much subscription time is left.

The foregoing is a summary and thus contains, by necessity, simplifications, generalizations, and omissions of detail; consequently, those skilled in the art will appreciate that the summary is illustrative only and is not intended to be in any way limiting. Other aspects, inventive features, and advantages of the present invention, as defined solely by the claims, will become apparent in the non-limiting detailed description set forth below.

## BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be better understood, and its numerous objects, features, and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference symbols in different drawings indicates similar or identical items.

**Figure 1** is high level diagram of a Interactive Proximity Service Architecture;

**Figure 2** is a diagram of a bootstrap agent and lifecycle control agent being downloaded into a handheld device;

**Figure 3** is a diagram of Strip Information Elements being transmitted from a Strip Distribution Engine;

**Figure 4** shows the field information included in a Strip Information Element;

**Figure 5** is a high level flowchart showing an agent loading process and information exchange;

**Figure 6** is a flowchart showing the Bootstrap Agent loading process;

**Figure 7** is a flowchart showing the Lifecycle Control Agent Loading process;

**Figure 8** is a flowchart showing the Bootstrap Agent and Lifecycle Control Agent monitoring each other.

**Figure 9** is a flowchart showing information exchange between the handheld device and service provider;

**Figure 10** is a flowchart showing a Strip Information Element being received and processed; and

**Figure 11** is a block diagram of an information handling system capable of implementing the present invention.

## DETAILED DESCRIPTION

The following is intended to provide a detailed description of an example of the invention and should not be taken to be limiting of the invention itself. Rather, any number of variations may fall within the scope of the invention which is defined in the claims following the description.

**Figure 1** is high level diagram of an Interactive Proximity Service Architecture (IPSA). The core function of Interactive Proximity Service Architecture **100** is to transmit data from a single or multiple websites to a variety of wireless devices sharing the same proximity environment. The transmission of data is based not only on service provider actions, but also on user requests. Examples of data transmitted via the service include video replay and latest statistics of a player that just hit a home run during a baseball game, or audio excerpts of a painter's biography as the visitor is looking at his painting in a museum. Interactive Proximity Service Architecture **100** can be configured to communicate with handheld devices for a single event or for multiple events. For example, a baseball game may have one IPSA, and a football game in the same proximity may have a separate IPSA. As those skilled in the art can appreciate, a single IPSA can also be configured to support and communicate with multiple events (i.e. one IPSA supporting both a baseball game and a football game).

A subscriber carries cell phone **110**, personal digital assistant (PDA) **130**, or other handheld device **120** to an

event. Examples of other handheld devices includes electronic items such as a laptop computers. The subscriber enters an event and the handheld devices communicate with communication front end **105**. Communication front end **105** can be an infrared port, a wireless system such as a cellular or paging network. Communication front end **105** analyzes the signals from the handheld devices, and passes the information requests to web server **140**. For example, information requests can be in Hyper Text Transfer Protocol (HTTP) format. Web Server **140** communicates with Servlet Engine **150** and Transcoding Application **160**. Transcoding Application **160** ascertains the type of device accessing the site and applies the proper style to display the data. For example, the screen size and resolution of the device are used in determining the proper style to display the information. Web server HTTP requests trigger Java servlets in servlet engine **150**. Servlet engine **150** accesses database **170** for the requested information, such as downloadable video or text content. Database **170** includes basic information and may be updated with new static information from non-real time data provider **180** or real-time information from real-time data provider **190**. Database **170** information includes formats such as text, audio, and video.

**Figure 2** is a diagram of a bootstrap agent and lifecycle control agent being downloaded into a handheld device. An Agent at the Gate concept means that every time a customer attends an event (sports game, museum, conference, etc.) a unique agent for the event downloads to his handheld device. The process is performed in two steps whereby a Bootstrap Agent (BA) is downloaded to the

customer handheld device through the infrared port and the bootstrap agent in turn downloads the Lifecycle Controlled Agent (LCA) through a faster wireless link. Both BA and LCA have functionality that allows a mutual monitoring so if one agent fails, the other reloads and restarts the one which failed.

When customer **220** arrives at an event that includes Interactive Proximity services from Service Provider **200**, customer **220** downloads bootstrap agent **225** from the service providers' (**200**) infrared port **205**. Bootstrap agent **225** is downloaded into customers' handheld device **250** through customer's Infrared port **255**. The primary purpose of the Bootstrap agent is to download the Lifecycle Controlled Agent (LCA). The bootstrap agent includes transfer and security functionality such as event identifier **230**, monitoring functionality **235**, and security enforcements **240**. Event Identifier **230** is unique and is used as a discriminator so that there is no overlap between information exchanged in different events that happen in the same proximity range at the same time. Monitoring **235** and security enforcement **240** are used to monitor the proper operation of the Lifecycle Controlled Agent and to reload the LCA if the LCA stops functioning. Once the bootstrap agent is loaded into handheld proximity application **260**, the bootstrap agent sends request **270** through handheld device wireless port **265** to download the lifecycle control agent. When service providers wireless station **210** receives request **270**, wireless station transmits lifecycle control agent **275** that includes service time to live (STTL) **280** and class of service **285**. Service time to live **280** is part of the security information with a main purpose of

invalidating access to the services and to removing the agent after a certain period of time. This parameter may be upgraded on the fly during the event to meet specific service requirements. For example, the STTL could be extended for a football game that requires an overtime period to conclude. Or a museum can extend the STTL over several days according to the subscription taken by the customer. Class of service (COS) **285** represents different levels of services to which a customer can subscribe. The COS is defined by the event producer and may be different over the time even for the same type of event. Examples of COS are Audio, Text only, Video, and Video+. For Text only COS, the subscriber is allowed to receive and to request information in text format. For Audio, the subscriber receives all audio that is broadcast during the event. For Video COS, the subscriber receives all video that is broadcast during the event. For Video+ COS, the subscriber can interactively query additional video functionality such as slow motion replay or specific camera angles.

**Figure 3** is a diagram of Strip Information Elements being transmitted from a Strip Distribution Engine. Strip Distribution Engine **300** sends strips **310** to handheld devices **320** for a particular event. Strips **310** do not include all the data but includes elements necessary to retrieve, format, and display the information. The Information Proximity Service Architecture sends SIEs instead of pushing the whole information from the servers to the handheld devices in order minimize bandwidth usage. Agent **340** is internal to the handheld device and analyzes the strips that are sent to a handheld. Agent **340** authenticates the strip by analyzing the strips' Event

Identifier to prevent distribution of unauthorized information. After the security checking is completed, the strip is under the control of the local agent that scans the different fields and makes determinations according to the content of the fields. When the user wants to download data, the user sends request **350** to retrieve a particular piece of data. For example, request **350** can be for multimedia data such as video. Strip Distribution Engine sends multimedia data **360** to the handheld device. Multimedia information can be obtained from database **390** which can include video plus hypertext links. Data can also be obtained from database **380** which may contain video, or database **370** which may only contain text information.

**Figure 4** shows the field information in a Strip Information Element. Strip information Element (SIE) **400** contains multiple fields that allow the local agent and service provider to communicate to each other. The first field is Execution Field **410**. Execution Field **410** includes information that informs the handheld device whether data may be retrieved immediately or on user request. When immediate **414** is selected, the local agent initiates the connection of the wireless station to download the information upon receipt of the SIE. When on request **418** is selected, the local agent waits until the user asks for the specific information before downloading it. For example, live video information may be downloaded immediately, while replay video may be on user request.

Lifecycle Field **420** includes information that determines whether the information may be kept after been processed by the local agent. When "keep" option **424** is selected, the user is allowed to keep the data that has

been transferred to his handheld device. This field can be set up on a per strip element basis, allowing strict control over what the user is able to keep. For example, due to intellectual property rights limitations, this field could be set up to a value that prevents duplication of the retrieved information that contains intellectual property, but allow the user to keep information that does not contain intellectual property. Another example is that some data are transient at server level, and make it not possible to access the data after a certain period of time. In this case, the lifecycle field will also set up to a value that prevents the local agent to try to access the data. When "discard" option **426** is selected, the downloaded data is discarded from the user's device upon completion of the event. When conditional remove **428** is selected, data may also be accessed multiple times during a certain condition. For example, data may be accessed multiple times during a sporting event, but the data is discarded once the event is over.

Navigation Field **430** includes information for the handheld device to logically store the strip information elements. As the SIE's are downloaded to the handheld device, they are stored in a way that allows an easy access according to a dynamic navigation scheme. Since the display sequence at time *t* may differ from the display sequence at time *t+1*, each SIE carries information about the navigation. This information represents the location of the information in a display tree. When a new SIE is received, it is placed in a specific location in the tree and as the dynamic structure of the tree evolves in time, the position of the SIE moves across the tree. When insert

**432** is selected, the SIE is inserted between the specified SIE's. When remove **434** is selected, the SIE is removed from the display tree. When next **436** is selected, the SIE is stored in the next available location. When previous **438** is selected, the SIE is stored in the location prior to the last SIE in the display tree.

Persistence Field **440** includes information that specifies what kind of repeated requests are expected for the piece of information. The user can select a persistence option that determines where and how the information is stored. The persistence can be local on the handheld device or remote. If local **442** is selected, the persistence is stored on the handheld device. If remote **444** is selected, persistence is stored on a remote device. Two example fields shown for a remote device are printer **446** and disk **448**. If printer **446** is selected, persistence comes from an external printer. If disk **448** is selected, persistence is stored on a nonvolatile storage device, such as a magnetic disk device.

Security Field **450** includes information that pertains to the security of the information being transferred. Security Field **450** includes event ID **458** which is the unique identifier that is used as a first protection level. The event id allows the user to receive information for the particular event subscribed to, and not to receive information from a nearby event that has a different event id. Security Field **450** also includes key **454** which is a key from a public/private encryption key pair used by the local agent to protect sensitive data exchanged between the server and the client.

Configuration Field **460** includes information such as Service Time To Live (STTL) **464**, Server information **466**, and transcoding information **468**. STTL **464** is used by the local agent to release further access to services once time has expired. Server information **466** includes information that can be negotiated by the handheld devices, such as bandwidth information, available protocols, and status information. Transcoding information **468** includes information about how the data is displayed based on the screen size and resolution of the handheld device.

Id Field **470** includes Strip Information Element (SIE) Identifier **475**. SIE **475** is a unique identifier for SIE **400**. SIE Identifier **475** is different from the Event Identifier in that each SIE is assigned with a unique identifier that is mainly used to uniquely identify the data in the navigation tree.

Description Field **480** includes description information about the corresponding content. The description includes the address of the content on the server, such as URL **482**. The description can also include data **484** about the content, such as any additional cost to download the corresponding content which may be in addition to any subscription fees paid by the user. Description **480** also includes text description **486** which includes a short description that can be displayed to the user in order for the user to determine whether he wants to download the corresponding content.

**Figure 5** is a high level flowchart showing an agent loading process and information exchange. Processing commences at **500**, whereupon a subscriber enters an area

(step **510**), such as an event location. A determination is made as to whether the subscriber is new or is already a registered subscriber (decision **520**). If the subscriber is not new, decision **520** branches to "No" branch **524** whereupon a Lifecycle Control Agent is requested (step **550**). For example, a subscriber can have an annual subscription to a museum, and already be registered at the museum and already have a bootstrap agent loaded in his handheld device. On the other hand, if the subscriber is new, decision **520** branches to "yes" branch **528** whereupon a subscription is activated for the event (step **530**). Subscription activation may also include receiving payment information, such as a credit card number, from the user and charging the user the corresponding subscription fee. After the subscription activates, a bootstrap agent loads into the subscribers handheld device (pre-defined process block **540**, see **Figure 6** for further details). After the bootstrap agent loads, the bootstrap agent requests a Lifecycle Control Agent (LCA) (step **550**) through handheld wireless port **554**. The LCA may be loaded if the handheld device does not yet have an LCA or if it is determined that an LCA currently loaded on the handheld device is outdated and needs to be upgraded with a new LCA version. The handheld wireless port sends the request to system wireless port **558** and receives the Lifecycle control agent in the same manner. A determination is made as to whether the LCA has been received (decision **560**). If the LCA has not yet been received, decision **560** branches to "No" loop **554** whereupon processing loops back and waits for the LCA. On the other hand, when the LCA is received, decision **560** branches to "Yes" branch **558** whereupon the LCA loads (pre-defined process block **570**, See **Figure 8** for further details). The

LCA is used for downloading content corresponding to the subscribed event. Agent Monitoring also commences (pre-defined process block **575**, see **Figure 8** for further details) whereupon the bootstrap agent and the Lifecycle Control Agent each monitor each other and restart one another in the event of a failure. The subscriber is now ready for information exchange (pre-defined process block **580**, See **Figure 9** for further details) during which time the Lifecycle Control Agent is used to download various content associated with the subscribed event. When information exchanges has completed, for example at the end of the event, processing terminates at **590**.

**Figure 6** is a flowchart showing the Bootstrap Agent loading process. Processing commences at **600**, whereupon the handheld receives a bootstrap agent (step **610**) through handheld Infra Red (IR) port **620**. Handheld IR port **620** receives the bootstrap agent from system IR port **630**. Once the bootstrap agent is received, the bootstrap agent is initialized (step **640**) and Event Identifier is stored (step **650**) in Handheld Proximity Application **660**. Event ID is unique in time and space and is used as a discriminator to assure that there is no overlap between information exchanged in different events that happen in the same proximity range at the same time. Bootstrap agent security settings are loaded in handheld proximity application **660** (step **670**) along with the Lifecycle control agent monitor (step **680**). The security settings and LCA monitor are used to ensure proper operation of the LCA. If the LCA is determined to be inoperable when it should be operational, the bootstrap agent restarts the LCA (see **Figure 8** for further details). After the bootstrap agent information is

loaded into handheld proximity application **660**, processing returns at **690**.

**Figure 7** is a flowchart showing the Lifecycle Control Agent Loading process. Processing commences at **700**, whereupon the Lifecycle Control Agent (LCA) is initialized (step **710**). Class of Service (COS) information is retrieved from the LCA (step **720**) and loaded into Handheld Proximity Application **730**. Examples of COS are text, video, and video plus. A determination is made as to whether the handheld is capable of the Class of Service (decision **740**). For example, if the Class of Service is video, the handheld should have the capability of playing video. If the handheld is not capable of the COS, decision **740** branches to "No" branch **744** whereupon a error is returned (step **750**) and processing returns at **760**. On the other hand, if the handheld is capable of the COS, decision **740** branches to "Yes" branch **748** whereupon the bootstrap agent monitor is loaded (step **770**). The bootstrap agent monitor is used to ensure the proper operation of the LCA. If the bootstrap agent is determined to be inoperable when it should be functioning properly, the LCA restarts the bootstrap agent. Service time to live is loaded (step **780**) into timer **735** that tracks how much time is remaining for the Lifecycle Control Agent to be active and processing returns at **790**.

**Figure 8** is a flowchart showing the Bootstrap Agent and Lifecycle Control Agent monitoring each other. Agent monitoring commences at **800**, whereupon the Lifecycle Control Agent (LCA) status is retrieved (step **810**) from handheld proximity application **820**. The LCA status includes information about whether the LCA is functioning properly.

A determination is made as to whether the LCA is active and functioning properly (decision **830**). If the LCA is not functioning properly, decision **830** branches to "No" branch **835** whereupon the LCA is restarted (pre-defined process block **840**, See **Figure 7** for further details). On the other hand, if the LCA is functioning properly, decision **830** branches to "Yes" branch **845** whereupon the bootstrap agent status is retrieved (step **850**) from handheld proximity application **820**. A determination is made as to whether the Bootstrap agent is functioning properly (decision **860**). If the bootstrap agent is not functioning properly, decision **860** branches to "No" branch **865** whereupon the BA is restarted (pre-defined process block **870**, See **Figure 6** for further details). On the other hand, if the BA is functioning properly, decision **860** branches to "Yes" branch **875** whereupon a determination is made as to whether the monitoring continues (decision **880**). If the user decides to stop information exchange activity, or the event is over, decision **880** branches to "No" branch **888** whereupon monitoring ends at **890**. On the other hand, if the event is ongoing, decision **880** branches to "Yes" loop **884** whereupon the monitoring process starts over.

**Figure 9** is a flowchart showing information exchange between the handheld device and service provider. Processing commences at **900**, whereupon the Service Time To Live (STTL) is retrieved (step **905**) from the handheld proximity application. The STTL includes information about how long the handheld device is allowed to exchange information based on the length of the event. A determination is made as to whether the STTL is expired (decision **910**). If the STTL is expired, decision **910**

branches to "Yes" branch **915** whereupon an expiration message is reported (step **920**). The lifecycle control agent is removed from the handheld (step **925**) and processing returns at **930**. On the other hand, if more time remains for the service, decision **910** branches to "No" branch **935** whereupon a request for content is performed at **940**. The user request is sent from handheld wireless port **945** to system wireless port **950**. Service Provider Proximity Application **955** determines the corresponding content and sends it to the handheld device through system wireless port **950**. The requested information is received (step **960**) through handheld wireless port **945** whereupon strip information element (SIE) processing takes place (pre-defined process block **965**, See **Figure 10** for further details). A determination is made as to whether more strips are being processed. If no more strips are being processed, decision **970** branches to "No" branch **975** whereupon processing returns at **985**. On the other hand, if more strips will be processed, decision **970** branches to "Yes" Loop **980** whereupon processing continues.

**Figure 10** is a flowchart showing a Strip Information Element (SIE) being received and processed. Processing commences at **1000**, whereupon processing compares event ID's for received SIE **1010** and authorized event ID from handheld proximity application **1015** (step **1005**). A determination is made as to whether the handheld device is authorized to receive the SIE (decision **1020**) based on the event ID comparison. If the handheld device is not authorized to receive the SIE, decision **1020** branches to "No" branch **1022** whereupon the strip is ignored (step **1025**) and processing returns at **1030**. On the other hand, if the handheld device

is authorized to receive the SIE, decision **1020** branches to "Yes" branch **1024** whereupon the received SIE is stored in handheld proximity application **1015** (step **1035**). The SIE Execution field is retrieved at **1040** from handheld proximity application **1015**. The execution field includes information as to whether the data should be retrieved immediately or upon a user request. For example, live video information may be downloaded immediately, while replay video may be performed in response to a user request. A determination is made as to whether the data should be retrieved immediately or on user request (decision **1045**). If the data is to be retrieved immediately, decision **1045** branches to "Yes" branch **1049** whereupon the SIE URL location is retrieved and the data is downloaded from Service Provider Proximity Application (**1060**) and the downloaded data is displayed on the display screen (step **1055**). On the other hand, if the data is downloaded on user request, decision **1045** branches to "No" branch **1047** whereupon processing waits for a user request (step **1050**). When the user requests the data, processing continues from step **1050** whereby the SIE URL location is retrieved and the data is downloaded from Service Provider Proximity Application (**1060**) and the downloaded data is displayed on the display screen (step **1055**). The lifecycle field is retrieved at step **1060** which includes information as to whether the data can be stored after viewing, or if the data is discarded after viewing. For example, data that is readily available on the Internet, like a player's statistics, may be stored on the subscribers handheld device after the event. A determination is made as to whether the data is storable after viewing (decision **1065**). If the data is not storable, decision **1065** branches to "No"

branch **1067** whereupon the data is removed after viewing (step **1070**). On the other hand, if the data can be stored after viewing, decision **1065** branches to "Yes" branch **1069** whereupon the data is stored if the user requests (step **1075**), and processing returns at **1080**.

**Figure 11** illustrates information handling system **1101** which is a simplified example of a computer system capable of performing the server and client operations described herein. Computer system **1101** includes processor **1100** which is coupled to host bus **1105**. A level two (L2) cache memory **1110** is also coupled to the host bus **1105**. Host-to-PCI bridge **1115** is coupled to main memory **1120**, includes cache memory and main memory control functions, and provides bus control to handle transfers among PCI bus **1125**, processor **1100**, L2 cache **1110**, main memory **1120**, and host bus **1105**. PCI bus **1125** provides an interface for a variety of devices including, for example, LAN card **1130**. PCI-to-ISA bridge **1135** provides bus control to handle transfers between PCI bus **1125** and ISA bus **1140**, universal serial bus (USB) functionality **1145**, IDE device functionality **1150**, power management functionality **1155**, and can include other functional elements not shown, such as a real-time clock (RTC), DMA control, interrupt support, and system management bus support. Peripheral devices and input/output (I/O) devices can be attached to various interfaces **1160** (e.g., parallel interface **1162**, serial interface **1164**, infrared (IR) interface **1166**, keyboard interface **1168**, mouse interface **1170**, and fixed disk (HDD) **1172**) coupled to ISA bus **1140**. Alternatively, many I/O devices can be accommodated by a super I/O controller (not shown) attached to ISA bus **1140**.

BIOS **1180** is coupled to ISA bus **1140**, and incorporates the necessary processor executable code for a variety of low-level system functions and system boot functions. BIOS **1180** can be stored in any computer readable medium, including magnetic storage media, optical storage media, flash memory, random access memory, read only memory, and communications media conveying signals encoding the instructions (e.g., signals from a network). In order to attach computer system **1101** to another computer system to copy files over a network, LAN card **1130** is coupled to PCI bus **1125** and to PCI-to-ISA bridge **1135**. Similarly, to connect computer system **1101** to an ISP to connect to the Internet using a telephone line connection, modem **1175** is connected to serial port **1164** and PCI-to-ISA Bridge **1135**.

While the computer system described in **Figure 11** is capable of executing the invention described herein, this computer system is simply one example of a computer system. Those skilled in the art will appreciate that many other computer system designs are capable of performing the invention described herein.

One of the preferred implementations of the invention is an application, namely, a set of instructions (program code) in a code module which may, for example, be resident in the random access memory of the computer. Until required by the computer, the set of instructions may be stored in another computer memory, for example, on a hard disk drive, or in removable storage such as an optical disk (for eventual use in a CD ROM) or floppy disk (for eventual use in a floppy disk drive), or downloaded via the Internet or other computer network. Thus, the present invention may

be implemented as a computer program product for use in a computer. In addition, although the various methods described are conveniently implemented in a general purpose computer selectively activated or reconfigured by software, one of ordinary skill in the art would also recognize that such methods may be carried out in hardware, in firmware, or in more specialized apparatus constructed to perform the required method steps.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects and, therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those with skill in the art that if a specific number of an introduced claim element is intended, such intent will be explicitly recited in the claim, and in the absence of such recitation no such limitation is present. For a non-limiting example, as an aid to understanding, the following appended claims contain usage of the introductory phrases "at least one" and "one or more" to introduce claim elements. However, the use of such phrases should not be construed to imply that the introduction of a claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and

indefinite articles such as "a" or "an"; the same holds true for the use in the claims of definite articles.